

INVERSE DYNAMIC ANALYSIS OF THE STIFLE JOINT IN LABRADOR RETRIEVERS WITH CRANIAL CRUCIATE LIGAMENT DEFICIENCY

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INTRODUCTION

Inverse dynamic analyses combine kinematics, morphometric and ground reaction force (GRF) data in a segmental model of the limb, and have greatly contributed to the understanding of normal and pathological movement in humans (Winter, 2005). Cranial cruciate ligament (CCL) disease is the leading cause of degenerative joint disease in the stifle (knee) of dogs. No published information describes the net joint moment, power or reaction forces associated with lameness due to CCL disease, therefore limiting our knowledge about CCL-deficient gait mechanism. The objectives of this study were to (1) quantify for net joint moments, powers and joint reaction forces (JRF) during the stance and the swing phases of the gait cycle across the stifle joints in Labrador Retrievers with and without CCL disease, and (2) investigate differences in joint mechanics between normal, CCL-deficient and contralateral hind limbs.

METHODS AND PROCEDURES

The inertial properties were determined using 3-dimension computerized tomography images in 14 normal dogs and 10 dogs with unilateral CCL-deficiency. Thirteen spherical reflective skin markers identified bilateral thigh, crus and foot segments. Kinematic data of trotting dogs were collected using a 6-camera optical motion capture system (Vicon 460, Lake Forest, CA) synchronized with a

force plate (AMTI, model BP600900, Watertown, MA). A minimum of 3 valid trials were collected for each hind limb. X-, y- and z-directions were defined as forward-backward, medio-lateral and vertical, respectively (Figure 1). An inverse dynamic approach was used to compute, in the sagittal plane, stifle net moment (in Nm/kg), power (in W/kg) and joint reaction force (peak in N/kg, and impulse in N.s/kg) during the stance and swing phases of the gait cycle. Mann-Whitney and Wilcoxon tests were used to compare data between groups.

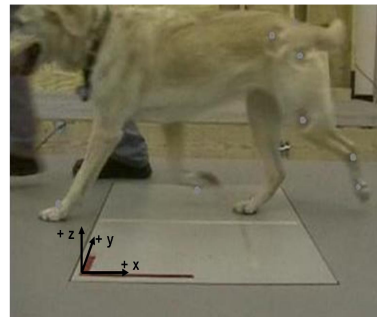


Figure 1: Dog trotting over the force plate with reflective markers on specific bony prominences.

RESULTS

This study documents for the first time gross differences in stifle joint mechanics between normal, CCL-deficient and contralateral limbs in dogs (Table 1). Curves of mean \pm SE for net moment and power values are plotted to reflect between-limb variation within each group (Figure 2). Moment, power and JRF patterns were similar in shape, but amplitudes were larger for contralateral limbs compared to normal limbs, and for normal compared to affected limbs. The amplitude of peak power

generation in late stance in contralateral limbs was about 3 times that measured in normal limbs and 15 times greater than that of CCL-deficient limbs.

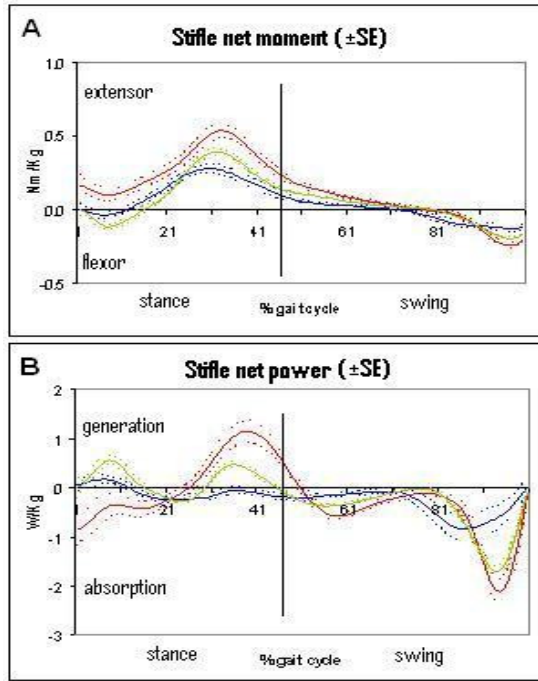


Figure 2: Mean (\pm SE) of stifle joint net moment (A) and power (B) for normal (green), CCL-deficient (blue) and contralateral (red) limbs.

DISCUSSION

The only previous publication of stifle kinetics in dogs was based on a small sampling of healthy, musculoskeletal disease-free Labradors ($n=3$) and Greyhounds ($n=4$) (Colborne et al, 2005). Our study reports, for the first time, net moment, power and JRF

around the stifle joint in Labrador Retrievers with or without CCL disease. Reductions in stifle joint net moment and power peaks and in stifle JRF peaks and impulses were interpreted as modifications adopted to reduce or avoid painful mobilization of the injured stifle joint (Andriacchi, 1990). Kinetics data identified an advanced activity of the contralateral side (increased loading and power generation), which may correlate with the predisposition of contralateral limbs to CCL deficiency in dogs (Doverspike et al, 1993).

SUMMARY

This study describes for the first time gross differences in stifle joint mechanics between normal, CCL-deficient and contralateral limbs indicating a reduced activity of the injured side compensated by an advanced activity of the contralateral limb.

REFERENCES

- Andriacchi (1990) *J. Biomech*, 23:99-105
 Colborne, Innes, Comerford et al (2005) *Am J Vet Res*, 66:1563-1571
 Doverspike, Vasseur, Harb et al (1993) *J Am Anim Hosp Assoc*, 29:167-170
 Winter (2005) *Biomechanics and Motor Control of Human Movement*. New York, Wiley

ACKNOWLEDGEMENTS

The authors thank John Jang for his assistance with data collection and the AVMA for her financial support.

Measurement		CCL-deficient	Contralateral	Normal
Moment (N.m/kg)	flexor peak stance	-0.08 (\pm 0.05) A	0.03 (\pm 0.09) B	-0.17 (\pm 0.07) C
	extensor peak stance	0.31 (\pm 0.12) A	0.57 (\pm 0.15) B	0.42 (\pm 0.14) A
	flexor peak swing	-0.15 (\pm 0.03) A	-0.26 (\pm 0.06) B	-0.21 (\pm 0.04) C
Power (W/kg)	peak generation	0.10 (\pm 0.27) A	1.36 (\pm 0.83) B	0.64 (\pm 0.40) C
	peak absorption	-1.06 (\pm 0.58) A	-2.33 (\pm 0.46) B	-1.95 (\pm 0.33) B
JRF (N.s/kg)	vertical peak	-3.02 (\pm 1.70) A	-6.51 (\pm 0.85) B	-5.98 (\pm 0.99) B
	vertical impulse	0.41 (\pm 0.23) A	1.02 (\pm 0.17) B	0.87 (\pm 0.13) C
	propulsion peak	0.71 (\pm 0.24) B	1.09 (\pm 0.23) A	0.85 (\pm 0.22) B
	propulsion impulse	0.11 (\pm 0.03) B	0.15 (\pm 0.37) A	0.12 (\pm 0.02) B
	braking peak stance	-0.27 (\pm 0.25) A	-0.57 (\pm 0.39) B	-0.80 (\pm 0.20) B
	braking impulse stance	0.01 (\pm 0.01) A	0.03 (\pm 0.02) B	0.05 (\pm 0.01) B
	braking peak swing	-0.51 (\pm 0.14) A	-0.89 (\pm 0.23) B	-0.71 (\pm 0.16) C
	braking impulse swing	0.04 (\pm 0.01)	0.04 (\pm 0.01)	0.04 (\pm 0.01)

Table 1: Mean (\pm SD) of net moment, power and JRF for the stifle joint of normal, CCL-deficient and contralateral limbs. **A, B, C:** groups with different letters differ statistically.